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# Symbiotic Data Platform

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A Receptive-Responsive Tool for Building Thermal Comfort Optimization

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## Synopsis

By the on going research project: 'Symbiotic Data Platform', the main objective is to combine the existing technologies (which are; Building Information Modeling and Internet of Things), and existing data to formulize an upgraded network and make use of the floating information for optimizing the building energy performance, the user satisfaction and ambiental quality, as well as enhancing productivity, energy efficiency and sustainability. While proposing the platform, the objective is to empower the user by their 'own' data flow.

The main aim is to create '*Real-Time Information Models*' that takes reference from collected data from the sensor and using the existing information form BIM. The real-time data and the BIM data can be monitored, or used as a control factor for decision making as well as automation for the smart environments. Even though the platform can address various fields on a conceptual framework, yet, to simplify the testing of functioning, this paper will only focus *on the thermal qualities and user comfort* regarding the temperature data.

On this paper, the research focuses on the data collection prototype, the current under development stage of the interface, and the implication phase of the '*Symbiotic Data Platform*' and as well as it discusses further stages of the project.

**Key words:** BIM<sup>1</sup>, IoT<sup>2</sup>, Responsive Architecture, Interaction, Building Thermal Comfort Optimization.

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<sup>1</sup> Building Information Modeling

<sup>2</sup> Internet of Things

## 1. Introduction

'*Symbiotic Data Platform*' is an interdisciplinary research project, which includes Building Information Modelling, interaction, computation, data mining, sensor technologies, modelling and simulation, architectural and engineering vision and, social studies' insight. Main focus and objective of this paper upon the platform is to analyse the occupant behaviour regarding to EBC – Annex 66, Definition and Simulation of Occupant Behaviour in Buildings (EBC, 2013) and to optimize the satisfaction, comfort level, energy efficiency and the ambient quality of the space, by '*taking benefit of the existing BIM model of the building*' and combining this information with '*real-time data*'.

The platform uses the **real-time information models** to create interactive environments. As the term 'Interactive Architecture' indicates, those models "include contributions from the worlds of architecture, industrial design, computer programming, engineering, and physical computing." (FOX & KEMP, 2009) By the collaboration of the disciplines with the contemporary understanding, adapting the architecture to the conscience of the modern worlds' necessities and the users expectation is the design thinking behind the project. "The concept of embedded intelligence in buildings is not new; rather what makes it currently possible are cheap digital sensors, computer power to handle big streams of data, and the development of software specifically developed for on-going operations and maintenance of buildings." (KENSEK, 2014) Since the technologies of sensing and data collection became eligible and accessible, the design research that corresponds to digital data collection also augmented. Additionally, by the accurate data, the research quality also shows significant increase.

The significance of the research is to take benefit of the massive existing data of material, location, energy analysis, cost and function information for further – interactive use. This objective addresses both lean construction and sustainable environment concerns due to energy efficiency, material and digital means.

## 2. The User

*Symbiotic Data Platform is not a design tool.* The focus is the switch the potential use of BIM from being just only for the practitioners of construction industry to address the occupant of the building, by creating a new profit field for the future.

By combining two existing technologies and creating an interactive network, which would be operated by the '**occupants/citizens**', will create a new stage for BIM, which is '*the 7th stage: **interaction***'. The highly detailed model of the built environment will be used in daily life, by the occupant, without requiring design or engineering or modelling knowledge. People would be able to access the necessary information through the platform thanks to the existing BIM Model, for their own benefit of energy efficiency and comfort optimization.

On a further stage, the platform would link the facilitated data from the citizens, and create a more advanced network for urban usage, addressing public issues.



### 3. The Prototype

The proposal is creation of 'Real-Time Information Models' to control the user data by blending BIM with IoT. The proposal is introducing an 'interactive // occupant - operated BIM Tool'. To do so, the first attempt to test is the 'Prototype I'. This prototype collects the body temperature data by only surfaces, to collect real-time relation with existing thermal condition of the space. By the hardware, the sensor collects the body temperature of the user 'passively, by some time periods,' and the algorithm, checks if any change has to be done to stabilize the desired & personified thermal comfort level. Aim of the prototype is, visualizing occupant behaviour and controlling the optimum comfort of the occupant and enhance energy efficiency and productivity.

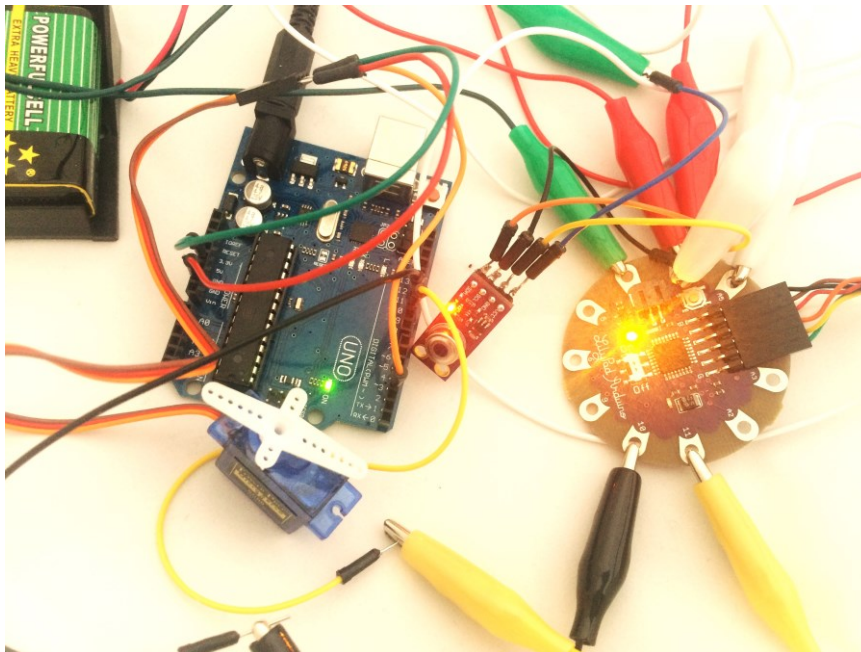


Figure 1.

The main objective to design a personal data collection device is to define the 'real-time data tracking' stage and to create '*human to machine*', '*machine to machine*', '*machine to human*' and '*human to environment*' interactions. The prototype scale is focusing on simply the thermal comfort. Collecting the data, which is, '*thermal qualities*' in this paper, is processed by the '*Data Tracking Device*' Prototype 1. The significance of this data collection prototype is the reason that the user data collection. The collected data is used for personalizing the thermal quality of the private space within the real-time crosscheck that is provided by the IoT system, and the BIM verification.

Hardware of the prototype includes Arduino Lilypad Main Board, Arduino Lilypad Xbee Shield, (2x - XB24C - ZigBee Connection), MLX90614 Non-Contact Infrared Temperature Sensor Module, 2x - Xbee Explorer Modules, GPS Module, cables, battery holders and coin cell batteries, Arduino Uno Board, 2 Servo Motors, a computer and a smartphone.

The application will collect real time data of body temperature. Following the data collection, the program will analyse the environmental comfort qualities, and

adapt the personal real-time data to the existing ambient situation. The variables are BIM - material data of the building, body temperature, environmental thermal analysis, HVAC types and efficiency, daily energy analysis. The output of the algorithm is the users desired thermal quality, and the modification of the HVAC according to an automated platform through the integration of BIM and IoT in real-time.

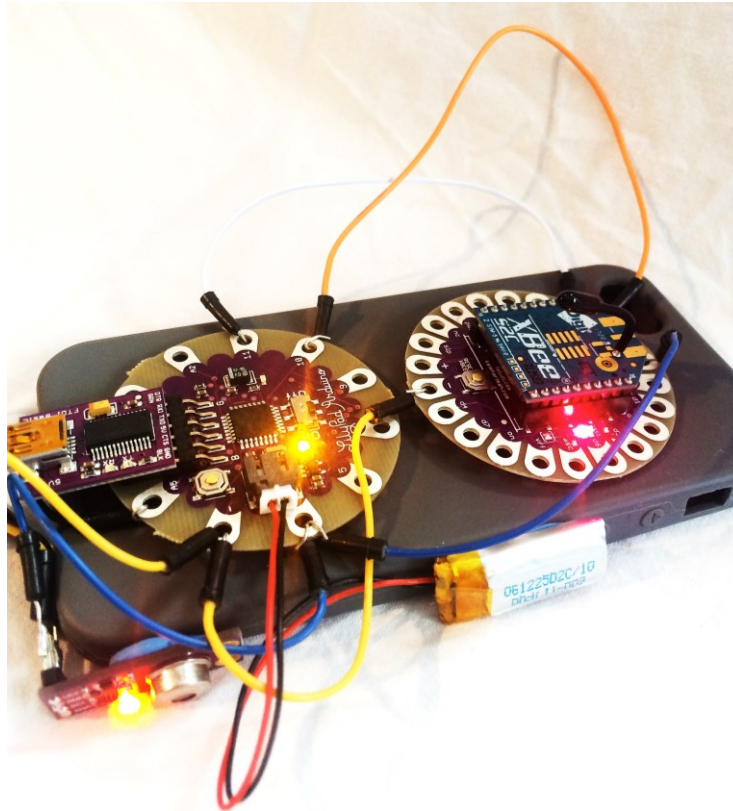


Figure 2.

The device have been designed as a smartphone cover, yet could be used as any other wearable when its detached; since its lightweight and simple. It can connect both the smartphone and the main computer. The device simply collects the users body-temperature within 10-minute time lapses. Every time that the user holds the smartphone, is a passive data collection for the platform. The data constantly get uploaded to the system. Additionally, the user can monitor and visualize the collected data, as well as the energy usage datasets, the 3D BIM of the private space and also the real-time mapping of the energy analysis. The prototype and the algorithm working vice-versa will stabilize the energy usage, enhance productivity, optimize occupant satisfaction, create a sustainable solution and act as a responsible factor in contemporary world.

#### 4. The Platform

By this platform, the building can feel and react to the current thermal condition and relatively; what the occupant desires regarding to that, by thermal comfort means. Since the data-flow constantly updates the HVAC system, without the user giving commands of making manual changes; the house can adjust the optimum thermal state for the user.

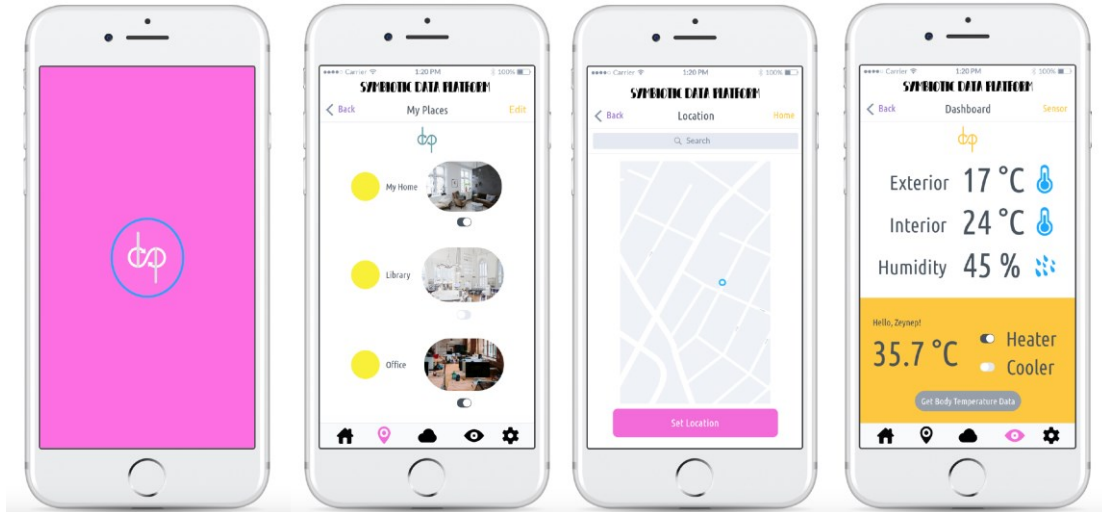


Figure 3.

#### 5. The Interface

As it is coined in BIM Handbook (EASTMAN, C, TEICHOLZ, SACKS, & LISTON, 2011) that, BIM enables the designer and the engineers 'virtually' construct the building. Within this new way of working, the ACE<sup>3</sup> industry had an advance technique for analyse, document and manage the project. Currently, at Europe, all the countries have the BIM adaptation procedure and BIM regulation in order to construct and register a building in legal means. Regarding the fact that by mid 2000's, the AEC Industry will apply the total shift on design thinking, and will adapt to BIM. As a consequence, the documentation of the built environment will be available for further use. The municipalities will have the documentation as BIM Models, and those data will be available upon request by practitioners when needed. As a consequence, BIM models holds giant amount information in digital means, but those data won't be used actively when the life starts inside of the buildings. 'Symbiotic Data Platform' aims to fill this open gap by creating a link between existing information and real-time data when the life is happening around the built environment.

Main research objective of the under-construction interface of the platform is to investigate on making benefit of already existing BIM files to extract construction details and information, to a new algorithm that will blend real-time weather/thermal information and also, the users' body temperature data by sensor interaction. The custom algorithm of the platform aims to interlace these variables, to create a real-time time energy analysis, which thereafter perform

<sup>3</sup> Architecture – Engineering – Construction

the thermal comfort optimization and energy savings by making the physical adjustments in the HVAC System of the specified space.

The Variables of the on progress 'Prototype 2' algorithm are as following:

1. BIM Extracted: Construction materials, opening details, location and orientation and insulation materials coefficients' data (R-Values)
2. Outdoor Weather Information from GPS
3. Indoor thermal information from indoor weather shield.
4. Users' body temperature data form the 'prototype 1'.
5. Users' current location from 'prototype 1'.

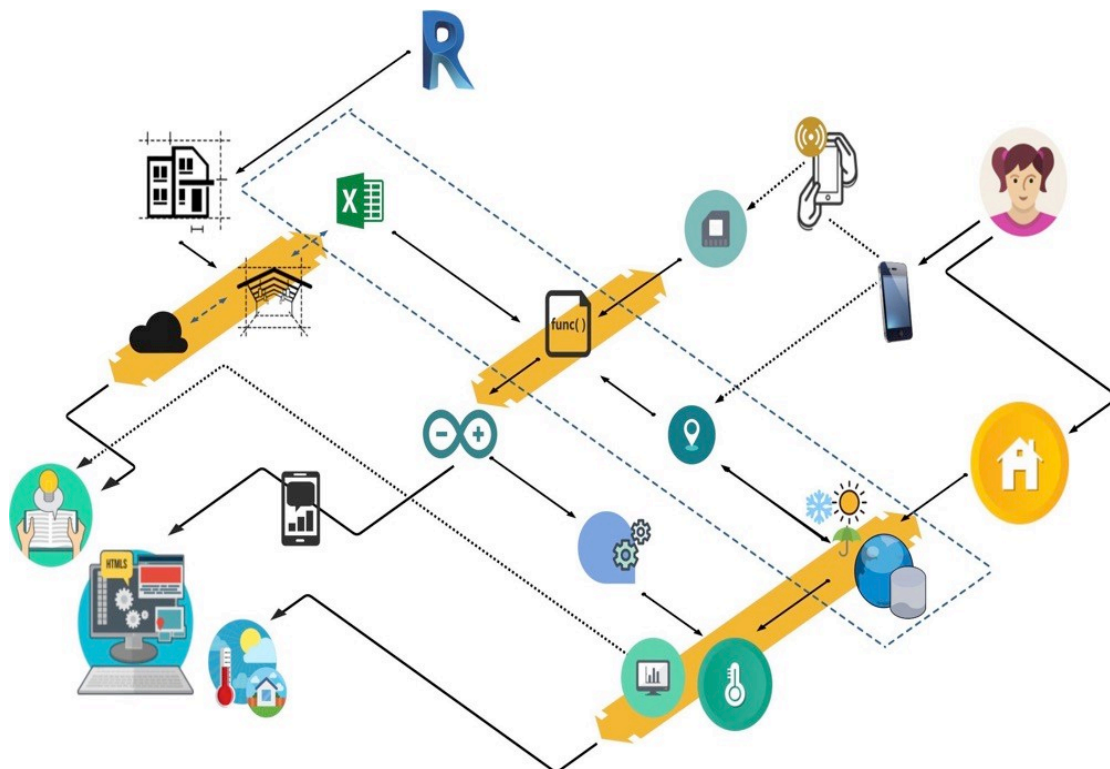


Figure 4.

## 6. Results & Discussion

By programing the Prototype by Arduino IDE, the following results of the interaction is successfully achieved. Apart from the IoT prototype, the BIM Integration is still on progress. Unfortunately there are some technical deficiencies of the prototype at this moment of the research; which are; the GPS Module cannot give very precise information indoors regarding exact coordinates of the user, and it is hard to locate the user in the rooms, and the X-Bee Module is very sensitive for the everyday use and the wireless connection is generally problematic.



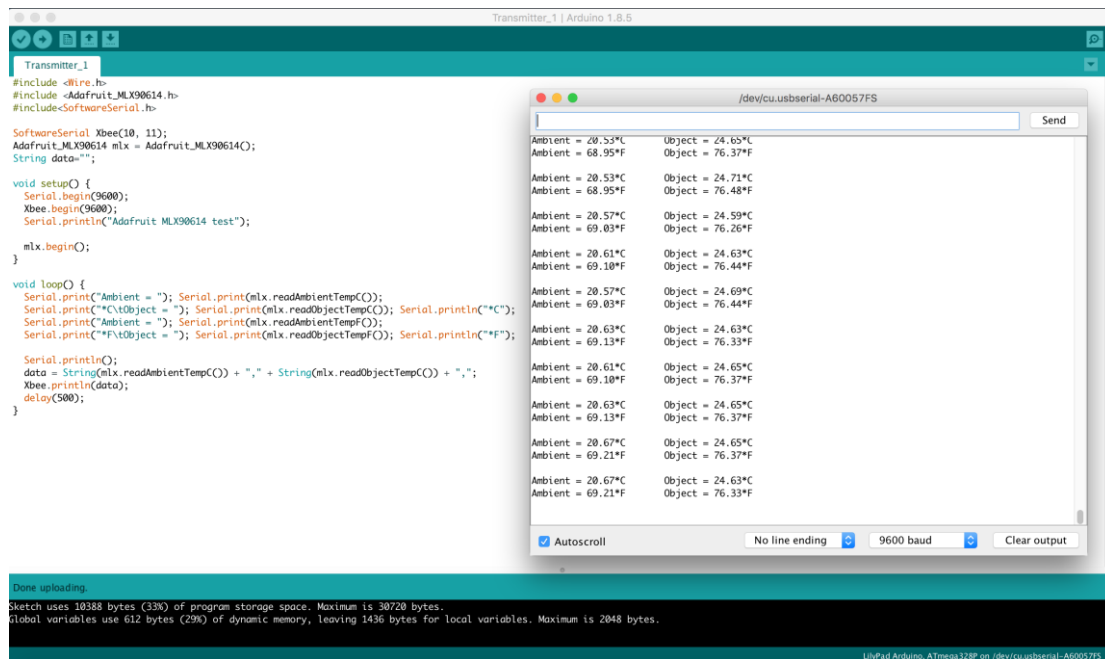


Figure 5.

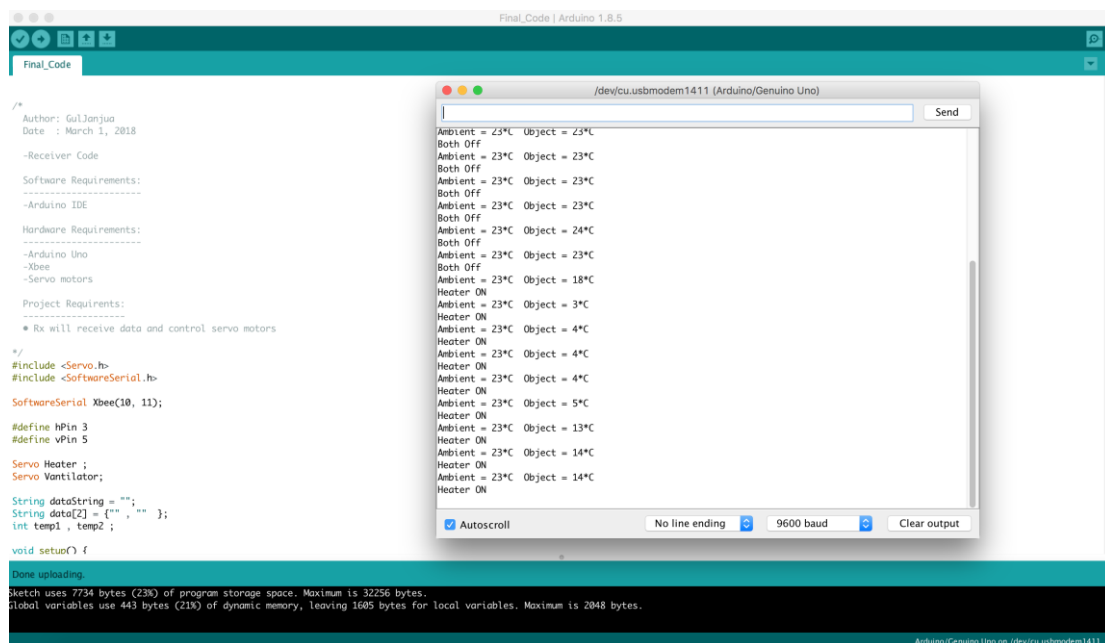


Figure 6.

## 7. Further Research

On a greater scale, the project can be developed as an urban interface, to create an information cycle/network between the smart homes to the smart cities by a new understanding of citizen participation. That project has a bottom-up theory, which is “*not making the city ‘smarter’ but making the user more active and the environment ‘responsive’.*”

Within '*Responsive City*' context, the Symbiotic Data Platform is explained by its possibilities of future research. The extension of this platform is explained

in a symposium proceeding, under the title of '*Active Public Space*'. (BIRGONUL, COCHO-BERMEJO, & SARRABLO, 2018) The objective of the proposed platform in urban level, is to create intelligence in the society regarding urban values and empower the citizen with collective values. Sharing data by the platform will create a stronger community network depending on the increase in productivity and efficiency in daily life of the citizens and will also upgrade the citizen participation in urban field. It is a promising project on the way of introducing a responsive city system by multi-ended outcomes. Simplifying and monitoring the existing data by the platform, will be the new solution for productivity, efficiency and sustainability in urban development.

The final product will be the end of the process by proposing a collective interface that addresses the contemporary concerns of the society. The approach of the research proposes the platform to achieve a new generation urban understanding, referring to the existing theories & computer programs to point out a new possibility to use BIM data.

## 8. Conclusion

Taking the reference of the results achieved from the Prototype I, the research is being developed by investigating the possibilities of adding BIM data to the prototypes' code, for mutual data interaction through BIM database and real-time information.

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## Biography

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